Comparison of Risk Methods.

Reviewer #1 wrote:

A brief comparison of reliability analysis methods must include also evaluation of uncertainty methods that are used for evaluation of a specific problem.

Answer could be:

Reliability analysis methods.

The risk associated with the potential failure of a hydraulic engineering system is the result of the combined effects of inherent randomness of external loads and various uncertainties involved in the analysis, design, construction, and operational procedures. Hence, to evaluate the probability that a hydraulic engineering system would function as design requires performing uncertainty and reliability analysis.

The reliability P_S, is defined as the probability of safety (or non-failure) in which the resistance of the structure exceeds the load, that is,

$$P_S = P(L \leq R) \quad (1)$$

Conversely, the failure probability, P_F can be computed as:

$$P_F = P(L > R) = 1 - P_S \quad (2)$$

Accordingly, the reliability is a function of random variables:

$$P_S = P\left[g(X_{L)} \leq h(X_R)\right] \quad (4)$$

The methods for evaluating this equation are:

Method	Observations
Direct Integration	The method requires PDFs be mathematical known or derived; very hard in real problems
Mean-Value First-Order Second-Moment (MFOSM)	Behavior function is expanded in a Taylor series at a selected point and evaluated with the first two statistical moments of random variables. Usually mean values of random variables
Advanced First-Order second-Moment (AFOSM) Method	The expansion of behavior function is made on failure surface. The point on this failure surface associated with the lowest reliability is the one having the shortest distance in the standardized space to the point where the means of the random variables are located. (Design point). This are named direct cosines to the expansion point. This method is applied to correlated and to no correlated normal random variables
Monte Carlo Simulation	This is a general method tp estimate statistical properties of a random variable that is related to a number of random variables which may o may not be correlated. The generated parameter values are generated according to their distributional properties. The major disadvantage is its computational intensiveness. There are some variations of this method, like Latin hypercubic sampling, importance sampling and the reduced space approach.

The techniques for uncertainty analysis are:

Analytical Techniques	Observations
Fourier and Exponential Transforms	Are particularly useful when random variables are independent and linearly related. The convolution property of the Fourier transform can be applied to derive the characteristic function of the resulting random variable.
Mellin Transform	When the random variables in a function are independent and nonnegative and the functions g(X) has a multiplicative form.
First-order Variance Estimation (FOVE) Method	The method approximates a model involving random variables by the Taylor series expansion.
Rosenblueth's Probabilistic Point Estimation (PE) Method	Is a computationally straight forward technique for uncertainty analysis. It can be used to estimate statistical moments of any order of a model output involving several random variables which are either correlated or uncorrelated.
Harr's Probabilistic Point Estimation (PE) Method	To avoid the computationally intensive nature of Rosenblueth's Method, when the number of random variables is large, Harr, proposed an alternative probabilistic method which reduces the required evaluations from 2^N to 2N and greatly enhances the applicability of the PE method of practical problems.

$$\times \log \left[\frac{(3.72 - 0.0253\beta) + (0.5 + 0.0544\beta)}{3.72 - 0.0253\beta} \right] = 0$$

By trial-and-error: $\beta = 1.27$

2	N	1.037	−0.241	−0.323	$1.00 + 0.0323\beta$
	C_c	0.487	−0.508	−0.681	$0.396 + 0.0674\beta$
	e_o	1.137	0.209	0.280	$1.19 - 0.05\beta$
	H	169.60	−0.126	−0.166	$168.00 + 1.394\beta$
	p_o	3.688	0.117	0.157	$3.72 - 0.0292\beta$
	Δp	0.569	−0.409	−0.548	$0.5 + 0.0548\beta$

Failure equation:

$$2.5 - (1 + 0.0323\beta) \frac{0.396 + 0.0674\beta}{1 + (1.19 - 0.05\beta)} (168 + 1.394\beta)$$

$$\times \log \left[\frac{(3.72 - 0.0292\beta) + (0.5 + 0.0548\beta)}{3.72 - 0.0292\beta} \right] = 0$$

By trial-and-error: $\beta = 1.27$

The failure point, therefore, is

$$n^* = 1.041,\ c_c^* = 0.482,\ e_o^* = 1.127,\ h^* = 169.8,\ p_o^* = 3.683,$$

$$\Delta p^* = 0.570$$

The probability of excessive settlement then is

$$p_F = 1 - \Phi(1.27) = 0.102$$

EXAMPLE 6.12 (*Spillway Capacity*)

Inadequate spillway capacity to carry the inflow water during an extreme flood is a major cause of dam failure. For a spillway with an uncontrolled overflow ogee crest, the discharge is given by (Bureau of Reclamation, 1977)

$$Q_c = NCLH^{3/2}$$